Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

ON THE SPINNERETS, CRIBELLUM, COLULUS, TRACHEÆ AND LUNG BOOKS OF ARANEADS.

BY THOMAS H. MONTGOMERY, JR.

This paper presents observations on the ontogeny of the organs mentioned in the title, together with notes on the anatomy of the cribellum and colulus and with certain considerations on the broader morphological relations of these various organs.

The embryos of the spiders examined were killed in Carnoy's fluid (absolute alcohol, chloroform and glacial acetic acid in equal parts, with corrosive sublimate to saturation), an excellent fixative that makes it possible to cut with ease good series of paraffine sections; it has the disadvantage of frequently producing an extra ovat of yolk in the earlier stages. After fixation and hardening the egg membranes are readily removed with needles. In order to secure good surface views of the abdomen after the stage of reversion it is best to cut off the cephalothorax, and with a knife to remove a considerable portion of the abdomen itself so as to allow the stain (preferably Delafield's hæmatoxyline) to penetrate evenly. The adult spinning organs with the cribellum or colulus are best examined in balsam after dehydration and clearing, and after the dorsal half of the abdomen has been cut away. Of *Theridium tepidariorum* and *Loxosceles rufescens* I secured accurately timed stages by breeding females in captivity. The material of *Theridium* was collected by me at Woods Hole, Massachusetts, and that of *Loxosceles, Evagrus* and *Filistata hibernalis* at Austin, Texas. I am obliged to Mr. Nathan Banks for the determination of these species.

1. COLULUS, CRIBELLUM AND SPINNERETS.

The first question to be taken up is the matter of the morphological relations of the colulus and cribellum to the spinnerets.

According to the classification of Simon (1892) two main groups of the Araneæ are distinguished: the Araneæ theraphosæ and the Araneæ veræ. The former include the families Liphistiidæ, Aviculariidæ and Atypidæ; of these the first are unique among all spiders in the possession of four pairs of true spinnerets (mammillæ), while most

Aviculariidæ possess only two pairs,[1] and the Atypidæ (the genus *Brachybothrium* excepted) possess three pairs. Almost all the Araneæ veræ have three pairs of spinnerets.[2] These discrepancies in number make it somewhat difficult to homologize the pairs of different groups, a difficulty briefly mentioned by Stevenson (1908).

The three pairs of spinnerets found in most of the Araneæ veræ are named in antero-posterior order: the anterior (inferior), the median, and the posterior (superior). Between the spinnerets of the anterior pair may be placed either a cribellum or a colulus, both of which are absent in the Theraphosæ. The cribellum was discovered by Blackwall (1839), and has been most thoroughly described by Bertkau (1882) as a small transverse plate, sometimes halved by a median carina, this plate provided with the very numerous minute pores which are the openings of multicellular spinning glands, and the spinning plate enclosed in a chitinous frame. In species possessing it the fourth pair of metatarsi are each provided with a row of recurved hairs, called the calamistrum and also dicovered by Blackwall; the latter is used as a comb to draw out the silk issuing from the cribellum—an operation that can be clearly seen in the larger species of *Filistata,* though it is performed with great rapidity. In mature males the cribellum is more or less rudimentary, for which Bertkau offers the valid explanation that adult males do not spin snares. Blackwall and Bertkau correctly interpreted the cribellum as a modified and fused pair of spinnerets, while Thorell (1870), who called it the "infra-mamillary organ," argued against such a comparison, though without cogent reasons.

The colulus or hypopygium (Menge, 1843) is a conical projection or small tubercle occupying approximately the place of the cribellum in some of the families of the Araneæ veræ which do not possess the cribellum. It has no spinning glands and there is no calamistrum associated with it. Menge compared it with a rudimentary cribellum, but Bertkau argued that the colulus is a simple integumentary fold representing the region between tracheal stigma and cribellum.

To decide with which of the three pairs of spinnerets of most Araneæ the two pairs of most Aviculariidæ correspond, I have examined some

---

[1] The exceptions are the genera *Hexathele* and *Scotinœcus* with a third (most anterior) pair of very small spinnerets; and *Anisapis* and *Diplothele* with only one pair.

[2] According to Simon, *l.c.*, less than three pairs are exhibited by the following: the Hadrotarsidæ, Palpimanidæ (except *Huttonia*), the Zodariid genera *Lutica, Hermipus, Mallinus,* and the Archæid *Mecysmauchenius*—these named genera having only one pair.

early stages of the Aviculariid *Evagrus*—this being to my knowledge the first account of the embryology of any Theraphosid. The earliest stage possessing extremities found is shown in fig. 28, Plate XIV, a lateral view. Next to the head lobe is found the cheliceron (*Chel.*), then the pedipalp (*Ped.*), then the four pairs of thoracal legs (*L.* 1–*L.* 4). The abdomen is remarkable in possessing only two segments (1, 2), whereas in other spiders at a corresponding stage the abdomen would be richly segmented, and in having a huge caudal lobe (*C. L.*) projecting forward. The next stage available is that of fig. 29, a ventral view of the abdomen: the two pairs of lung books (*Pul.*) have formed, the nerve ganglia (*N. C.*) are clearly marked, and there are indications of three pairs of spinnerets. Of the latter the anterior (*A. Sp.*) are only faintly marked thickenings, and evidently belong to the fourth abdominal segment; the median spinnerets (*M. Sp.*) are rounded projections just median to and in the same plane with the largest posterior spinnerets (*P. Sp.*), therefore outgrowths of the fifth segment. Three successive later stages, shown in figs. 30–32 respectively, show that the anterior spinnerets have disappeared and that it is those of the fifth segment, the median and the posterior, that persist into the adult. Thus the fourth segment, as shown clearly in figs. 30 and 31, produces no respiratory organs, but originates a pair of rudimentary spinnerets that subsequently disappear.

The two pairs of spinnerets of *Evagrus*, and of probably also other Aviculariids with that number, correspond to the median and posterior spinnerets of those araneads with three pairs; but the development shows that *Evagrus* retains in the embryo a slight trace of the anterior pair. This homology has been already suggested by Simon, on the basis of the relative position of the parts in the adult.

In the next place we may consider the colulus, an organ that has received only the scantiest attention. It may be best studied in Sicariids where it attains its greatest size, and the following account applies to the genus *Loxosceles*.

In an adult individual the form and position of the colulus is shown on ventral view in fig. 26, Pl. XIII. It is an unpaired conical projection (*Col.*) between the anterior spinnerets (*A. Sp.*), its base confluent with their bases and at some distance behind the tracheal stigma (*T. St.*). The transverse line in the figure which crosses it from left to right represents the border of a skin-fold just dorsal to it and to the spinnerets, and this fold is deeply indented in the median line. Its free apex is directed ventro-caudad; its surface bears simple hairs like those on the ventral surface of the abdomen, and the small circles indicate the insertion points of these hairs. A median section of it is represented in fig. 25, where the apex is at the left and the dorsal border uppermost. It is covered by a cuticula (*Cut.*), which is less thick than that of the adjacent body surface, beneath which is a hypodermis (*Hyp.*) considerably thicker than that of the rest of the abdomen. The interior of the organ is a blood-space (*Bl. Cav.*), shown by stippling, containing neither glands nor muscles, though muscles insert near its base. The colulus is equally developed in both sexes. Thus it is a simple integumentary extension with a large axial blood cavity. An organ of its volume must surely fulfill some important function. Its thickened hypodermis might suggest sensory nature. But I think it may be more likely a supplementary respiratory organ, for which the combination of relatively thin cuticula and vascular space would speak, and furthermore the tracheæ are relatively poorly developed in this species.

In *Peucetia* (Oxyopid) and *Lathrodectus* (Theridiid) it is about twice as long as broad, shorter and relatively broader in Dysderids and Argiopids. But in the Agalenids I have found the most interesting relations: in *Tegenaria derhamii* it is a plate about twice as broad as long, in *Hahnia bimaculata* a transverse plate eight times as broad as its antero-posterior length, while in *Agelena nœvia* there are a pair of small plates completely separated in the mid-line by a little more than their diameter and inserted well anterior to the roots of the anterior spinnerets. The last case is interesting, for it exhibits the colulus in a distinctly paired condition, the first case of such a relation yet known.

We have next to consider the ontogeny of colulus and spinnerets. Salensky (1871) first proved that the appendages of the fourth and fifth abdominal appendages become the spinnerets. He found the fourth appendages originate the anterior spinnerets, the fifth the posterior, and that the median spinnerets "do not develop from the abdominal feet, but appear between them" (I cite from Jaworowski, for I cannot read the original Russian). This origin of the anterior and posterior spinnerets has been confirmed by Locy (1886), Morin (1887), Kishinouye (1890) and Korschelt (1892), while Barrois (1878), Balfour (1880) and Schimkewitsch (1887) erroneously held that the embryonic appendages disappear and that spinnerets are new formations. The most detailed and satisfactory account is that of Jaworowski (1895) of *Trochosa.* He found that after reversion each appendage of the fourth and fifth abdominal segments is bilobed, consisting of an outer sacculus (exopodite) and inner sacculus (endopodite); on the fourth segment the exopodites become the anterior spinnerets and the endopodites form a "rudimentary cribellum" (more strictly, colulus) that later disappears; on the fifth segment the exopodites become the posterior spinnerets, and the endopodites the median spinnerets. Wallstabe (1908) also found, in *Agelena*, that the median spinnerets arise by splitting off from the posterior pair.

I am able on embryos of *Loxosceles* to essentially confirm the account of Jaworowski and to trace the colulus to its adult condition. Fig. 17, Pl. XIII, represents that stage before reversion, when the maximum number of abdominal appendages is present, and there are seen to be six pairs of them, on segments 2 to 7 inclusive. The two most posterior pairs are the smallest and are temporary, for in the next stage, figs. 18, 19, of the beginning reversion they have disappeared and only the four anterior pairs persist.[3] Later, fig. 20, the third and fourth pairs of these appendages become the largest. The process of reversion brings them close together in the mid-line, and an interesting and decisive condition is exhibited in the stage of fig. 21. The fourth pair of appendages (*P. Sp.*) are approximated, and on the median side of each is an elongated thickening of the hypodermis, the first indication of the median spinnerets (*M. Sp.*). Between the third pair of appendages (*A. Sp.*) there is an undivided, so unpaired, thickening, the primordium of the colulus (*Col.*). My observations differ mainly from those of Jaworowski in finding the colulus to be unpaired at the start, and in finding that the colulus and the median spinnerets behind it do not arise as saccular endopodites of the embryonic appendages, but as thickenings immediately mesial to the appendages. This is a rather important difference, for Jaworowski's description would indicate a cleft condition of these appendages, such as is found in Crustacea, while I do not find such a condition. In *Loxosceles* the colulus and the median spinnerets would seem not to be parts of the appendages, but immediately contiguous to them. Figs. 22–24 show successive later stages, with lengthening of the three pairs of spinnerets and of the unpaired colulus, as well as the gradual extension forward of the largest pair of spinning glands.

The colulus, accordingly, arises as a hypodermal thickening between the anterior spinnerets, and the median spinnerets from a pair of thickenings between the posterior spinnerets. The only difference in *Loxosceles* is that the colulus has an unpaired origin; but this difference does not hold in all cases, for in *Trochosa* (Jaworowski) the colulus has a paired origin, and we have seen that in *Agelena* the colulus is a paired structure in the adult. Evidently colulus and median spinnerets are homodynamous.

---

[3] In the stage of figs. 18 and 19 there are eleven well-marked abdominal segments exclusive of the caudal lobe. The largest number yet described for araneads is twelve, which with the seven of the cephalothorax makes a total of nineteen. The three most posterior of them together with the caudal lobe constitute a projecting postabdomen, such as has been described for *Pholcus* by Claparède (1862) and Schimkewitsch (1887); this may be compared with that of *Evagrus*, fig. 28, Pl. IV.

I have examined the cribellum in *Filistata, Hyptiotes, Uloborus* and *Dictyna.* In the adult female of *Filistata* there is found a transversely oval plate between the anterior spinnerets and somewhat anterior to them. This plate (fig. 34, Plate XIV) shows a pair of spinning plates (*Cr. Pl.*), provided with numerous fine pores, and these spinning plates are set in the much larger chitinous frame; on the anterior portion of this frame are inserted hairs (their insertion points indicated by the small circles), which hairs are plumose like these of the venter and differ from them only in their much smaller size. These relations are essentially such as Bertkau and others have described. But an important relation seems to have been heretofore entirely overlooked. The paired spinning plates, the cribellum proper, are only the uncovered free surfaces of a pair of appendages, the remaining portion of which is sunk below the chitinous frame. Thus when one examines on a cleared balsam mount the cribellum from the ventral surface, one sees at a higher focus of the microscope only the frame and the spinning plates; but on deeper focus one finds a column of delicate parallel spinning tubules, too fine to be represented on the scale of our drawing, extending from each spinning plate to the anterior edge of the frame. The lateral boundaries of these columns or appendages are shown in fig. 34 by the lines extending forward (upward) from the spinning plates (*Cr. Pl.*) to the upper border of the frame.

Further, each spinning plate shows a slight line of division at its middle, from which point of indentation a line extends some distance forward; this subdivision is probably due to the presence of a muscle (as it is certainly in some other species), though I could not clearly recognize a muscle. In other words, the spinning plates are merely the free, uncovered apices of a pair of spinnerets, the greater region of which lie covered by the cuticular frame. Or the relation might be represented in another way: the cribellum of *Filistata* is a pair of spinnerets mesially approximated, their glands opening distally (on the spinning plates), and across and around these spinnerets has developed a cuticular frame.

This interesting relation in *Filistata* is further explained by a study of the embryo shown in fig. 33, Pl. XIV; no one has previously described any developmental stage of the cribellum, for what Jaworowski described as a "rudimentary cribellum" in *Trochosa* was really a colulus. Fig. 33 represents a ventral view of the abdomen shortly after reversion, and the abdominal segments are well pronounced. The tracheal stigma (*T. St.*) is at the boundary of the third and fourth segments. On the fourth segment are found the anterior spinnerets (*A. Sp.*), and between them a pair of large thickenings (*Cr.*), the paired primordium of the cribellum. On the fifth segment are seen the posterior spinnerets (*P. Sp.*), and between them the median spinnerets as a pair of thickenings (*M. Sp.*). The resemblance of the cribellum to the median spinnerets at this stage is very close, each consisting of a pair of elongate ectoblastic thickenings near the mid-line; and the cribellum is even larger than the median spinnerets. There can be no doubt in this case of the homodynamy of cribellum and median spinnerets.

Fig. 36 shows a ventral view of the cribellum of a mature female of *Hyptiotes cavatus*, and fig. 35 a similar view of that of *Dictyna volupis*. In both of these there is a distinct pair of muscles (*M.*) passing from the spinning plate (*Cr. Pl.*) to the anterior edge of the cuticular frame. In these species the spinning plate is not paired, nor yet is the deeper portion composed of the ductules paired, in which points these species appear much less primitive than *Filistata*. I find the cribellum of *Uloborus plumipes* to be very similar to that of *Hyptiotes*. In *Hyptiotes* the tracheal stigma (*T. St.*) is immediately contiguous to the frame of the cribellum, while in *Dictyna* (fig. 35) they are separated.

Thus we come to the conclusion that the spinnerets, colulus and cribellum all develop from the fourth and fifth abdominal segments; the anterior spinnerets and colulus or cribellum from the fourth, the median and posterior spinnerets from the fifth, as concluded by Jaworowski. The colulus and cribellum arise as elongate thickenings mesial from the appendages of these segments, the appendages becoming the anterior and posterior spinnerets. Colulus and cribellum, as we have seen, are in their development homodynamous with the median spinnerets of the segment behind them. Accordingly, colulus and cribellum arising in a similar position in corresponding segments must be considered essentially homologous organs, conformably with the view of Blackwall, whom Dahl (1901, 1904) has followed. The case of *Filistata* renders it a strong probability that the colulus and cribellum correspond with the antero-median spinnerets of *Liphistius*. The cribellum is a less degenerate structure than the colulus, because it still possesses spinning glands, is larger, and is more frequently paired.

These homologies might be shown tabularly as follows:

	SPINNERETS.			
Liphistiidæ.	Antero-lateral.	Antero-median.	Postero-lateral.	Postero-median.
Aviculariidæ.			Posterior.	Median.
Araneæ veræ.	Anterior.	Colulus or cribellum.	Posterior.	Median.

2. DEVELOPMENT OF THE TRACHEÆ.

Locy (1886), the first to mention the development of these structures, simply states that "upon the ventral surface appear the infoldings, from which are formed the tracheæ." Schimkewitsch (1887) is mistaken in saying that Balfour (1880) demonstrated the origin of tracheæ and lungs, for Balfour did not mention these organs. Schimkewitsch briefly mentions a stage in *Lycosa* before hatching where the tracheæ are already branched Kishinouye (1890) writes: "In the basal part of the second abdominal appendage, on the interior side, another ectodermic invagination is produced. It assumes the shape of a deeply invaginated tube and remains in this condition till after the time of hatching. The appendage itself is not invaginated and becomes from this time gradually shorter." Purcell (1895) states that the "entapophyses connected with the second (tracheal) pair of appendages become each drawn out into a long tube, to or near the blind, inner end of which the middle pair of endosternites is attached in the adult. These long tubes are represented by the two large trunks which form the tracheæ in the Attidæ, and by the medial pair of the four trunks which compose the tracheæ in most other Spiders (Agelenidæ, Drassidæ, Epeiridæ, Lycosidæ, etc.)."[4]

The preceding references to the tracheæ are all brief and not illustrated by figures. Simmons (1894) goes into the subject somewhat more fully; he finds the tracheæ arising before reversion behind the appendage of the third abdominal segment as a tubular, ectoblastic ingrowth, and the tube so produced to have an irregular folding of its wall, resembling to some extent the primary folds of the pulmonary invagination. After the stage of reversion he figures it as a simple tube without branching. The most recent paper is that of Janeck (1909); he did not see the earliest stages, but describes and figures a stage shortly after hatching with the beginning of the branching, and an advanced stage after reversion.

---

[4] My friend Dr. Purcell's brief but important preliminary paper deals mostly with the homologies of the tracheæ and entopoyhyses, on which subject he has now an extensive paper in press. I have not considered these relations In *Loxosceles* I find just latero-posterior to each appendage of the four anterior abdominal pairs a thickening which appears darker than the surroundings on stained surface views, these being marked x in figs. 20–24 of Pl. XIII. I have not determined whether these are apophyses or simple muscle insertions.

Accordingly, no one has figured the earliest stages of the tracheæ, and our knowledge of their development is very fragmentary.

In *Loxosceles* the conditions are as follows, as observed in surface views only. In the stages of figs. 17–19, Plate XIII, the appendages of the third abdominal segment (3) are simple rounded protuberances like those of the adjacent segments. Later, fig. 20, the appendage of the third segment becomes flatter and less distinct, and its elevated portion has taken on somewhat the shape of a quarter moon. At the stage of fig. 21, completed reversion, no elevated appendages are found in that segment, but at its posterior edge a transverse groove circularly enlarged at each lateral corner (*T. St.*). This condition persists through the stages of figs. 22 and 23, but at that of fig. 24 a pair of lateral tracheal branches, recognizable by being filled with air, and marked *Tr.*, are growing forward from the groove. The transverse groove is evidently the stigma leading into the vestibulum; and this stigma, developing at the posterior edge of the third segment, evidently arises behind the appendages of the segment. In the adult a larger median and four pairs of smaller lateral tracheæ extend forward from the vestibulum (fig. 27).

A better knowledge can be obtained from the study of sections which I have made of *Theridium.* At the time of reversion (fig. 16, Pl. XII) the abdominal appendages show much the same relation as in *Loxosceles,* though a narrow elevated ectoblastic ridge joins the second and third abdominal appendages (*2. Ap.*, *3. Ap.*). Sections of this stage (figs. 1, 2, Pl. XI) show the still heightened appendage (*3. Ap.*) of the third segment behind the pulmonary invagination and a distinct cœlomic sac (*Cœl.*) appertaining to it. But in subsequent stages (figs. 5, 7, 9) the appendage of the third segment disappears, the whole becoming flush with the remainder of the surface of that segment and without any process of invagination. It is not until after this appendage has disappeared entirely that the tracheal invagination takes place, and evidently as in *Loxosceles* behind the region where that appendage was. The first appearance of the tracheæ is seen in fig. 12, Pl. XII; the pulmonary stigma (*P. St.*) is at the posterior edge of the second segment, the tracheal (*T. St.*) not near this, as was the appendage of its segment, but close to the spinnerets (*Sp.*) at the posterior edge of the third segment. The stigma (*T. St.*) is a slight transverse groove, the trachea (*Tr.*) itself is a conical plug of ectoblast cells pushing into the archicœlic space between hypodermis and mesoblast (*Mes.*). Successive later stages of the ectoblastic impaired ingrowth (*T. St.*) are shown in median section in figs. 13–15; in these stages it already shows the division into an outer vestibulum, transversely widened, from the middle of which extends forward a single tracheal trunk, all with a thin chitinous lining. Fig. 15 is the stage of hatching, aged fifteen days, and shows just behind the stigma the still solid primordium of the colulus (*Col.*).

Thus the appendages of the third abdominal segment disappear entirely by merging with the circumjacent hypodermis and without forming any invagination. Quite independent of them and at the posterior margin of the third abdominal segment arises subsequently an unpaired ectoblastic inpushing, the vestibulum, from the middle part of which grows forward a little before the time of hatching a single tracheal trunk. I have not found any indications of folding of the tracheal wall like the pulmonary folding, such as Simmons described, and I would judge that the fold supposed by Simmons to be the trachea, represented in his fig. 8, is not a tracheal invagination at all, but merely the space dorso-posterior to the caudal lobe.

Reference may be made, in passing, to the relative position of the segments in the adult abdomen. The pulmonary stigma marks the posterior border of the second segment, the tracheal stigma (or, in Dipneumonids, that of the second pair of lungs) the posterior border of the third segment, while the anterior and posterior spinnerets mark the posterior regions of the fourth and fifth segments respectively. In *Loxosceles* the third segment comes to occupy a large portion of the venter, as shown in figs. 22–24, Pl. XIII. In *Filistata* (fig. 33, Pl. XIV) and *Evagrus* (figs. 30–32) the third segment is relatively much smaller After the stage of reversion the first abdominal segment cannot be distinguished externally from the second, and I am inclined to think it enters mostly into the composition of the pedicel.

3. DEVELOPMENT OF THE LUNG-BOOKS.

A considerable amount of work has been done upon the development of these organs since Salensky (1871) showed that they are derived from the appendages of the second abdominal segment.

Bertkau (1872) found that new lamellæ are added during the growth of the spider, each new one as an invagination from the region of the lateral corner of the stigma.

Locy (1886) figured and described two rather late stages, in the earlier of which "the lungs appear as oblong plates of cells, the large oval nuclei of which are arranged in parallel rows"; ultimately there result bicellular interlamellar pillars. Schimkewitsch (1887) described briefly a single rather late stage before hatching, the single figure of which given by him by no means proves that "the lungs of the embryo of *Lycosa saccata* consist of true tracheæ disposed in bundles." Morin (1887) found the lungs to be formed from thickenings at the bases of the appendages of the second abdominal segment, these thickenings becoming the opercula. What Bruce (1887) has described as a pulmonary operculum and lung cavity seems to be nothing more, and Kishinouye has previously made the criticism, judging from his figs. LXXIX and LXXIX,[1] than the caudal lobe at the stage of reversion and the space between it and the body wall; his account has accordingly no value. Kishinouye (1890) found "in the basal part of the first abdominal appendage of each side, there arises an ectodermic invagination whose opening faces away from the median line. . . . Of the wall of the invaginated pocket, that which faces the distal end of the appendage is much thicker than the opposite wall, filling the interior of the appendage. The cells composing it become after awhile arranged in parallel rows. Each two of these parallel rows adhering together produce the lamellæ of the lung-book. The external epithelium of the appendage which covers these lamellæ becomes the operculum of the lung-book after it is depressed in height." Simmons (1894) has given the fullest account up to his time, and the one most fully illustrated by figures. He described fully the method of invagination of the first abdominal appendage, found on its inner (mesial) surface a series of folds during this process of invagination, which folds he believed become the pulmonary lamellæ. There is, however, a great hiatus between the stages of his figs. 6 and 7, and the early embryonic folds do not lie in the same position as the adult lamellæ. Purcell (1895) found that "the earliest lung-leaves appear on the exposed posterior sides of the appendages before the latter have commenced to sink below the surface into the body, and completely outside of the basal sack," and, like Simmons, he concludes these become the adult lamellæ, but without tracing completely their later history. Wallstabe (1908) says he can corroborate Simmon's results, but does not enter into details.

Jaworowski (1894) presented a full account, well illustrated, but did not describe any stage earlier than one considerably later than reversion. He began with a stage where beneath the first abdominal appendage there is a saccular invagination, from which proceeds dorsally a tube dividing into several branches; "it is, however, clear that the so-called lungs of the spider in the embryonal condition are repeatedly branched tracheæ." These tracheal tubes ultimately disappear, and the definitive pulmonary lamellæ arise from parallel outgrowths of the vestibule (Vorraum).

Finally, the latest memoir, that of Janeck (1909) on *Lycosa,* is the most extensive, and he had not only an excellent series of stages, but he also made use of wax reconstructions. He describes thoroughly the infolding of the first abdominal appendage, finds that it develops a series of pronounced folds on its inner (mesial) surface, thus far essentially corroborating the observations of Simmons and Purcell, but, contrary to these writers, he finds these embryonic folds disappear. "Especially important is the demonstration that the folds of text figure 16, which many authors refer directly to the lung-leaves, have no relation at all to the lung . . . and the fold formation of these stages show themselves to be not even forerunners of the lung-leaves." The pulmonary lamellæ arise as secondary folds from a compact lung mass.

It will be seen that there are considerable differences of opinion, out of which it is hard to reach the true state of affairs. My observations are in entire disagreement with the conclusions of Schimkewitsch and Jaworowski, that the lungs arise as tubular tracheæ, and I believe that Jaworoski misinterpreted embryonic dorso-ventral muscles. Then neither of these authors described the earliest stages. With Purcell, I find folds appearing upon the posterior surface of the pulmonary appendages before it invaginates; but, in opposition to him and Simmons, and in agreement with Janeck, I find these folds are only temporary, and that the definitive lamellæ arise from a disassociated solid cell mass. Locy, Morin and Kishinouye were correct, so far as their observations went.

In *Theridium,* about the stage of reversion, the pulmonary stigma (*P. St.,* fig. 1, Pl. XI) is present as an ectoblastic invagination just behind the appendage of the second abdominal segment, and on the posterior face of this appendage are present three folds (*Lam. 1*). These embryonic folds may be called the primary lamellæ. In a later stage, shown in fig. 2 (a surface view of this stage is represented in fig. 16, Pl. XII), the pulmonary stigma (*P. St.*) has become deeper, and the primary lamellæ (*Lam. 1*) more pronounced. Later, fig. 3, the pulmonary sac or chamber has become a narrow space by the further insinking of the pulmonary appendage. Two primary lamellæ can be still distinguished (*Lam. 1*) but they have become relatively smaller; fig, 4 is a section of the same appendage but to one side of the stigma, where there is a closed tube beneath the outer ectoblast formed by overgrowth in the manner described by Janeck. Fig. 5 represents a stage still later; the whole pulmonary appendage has become flattened down to the surface of the abdomen, the primary lamellæ (*Lam. 1*) are not more than two in number and only slightly pronounced, while the anterior end of the pulmonary ingrowth is growing larger in the cephalad direction. In fig. 6, cut to one side of the stigma (so comparable with fig. 4 of an earlier stage), the anterior region of the solid ingrowth is divided into two parts, the beginning of the first two true or secondary lamellæ (*Lam. 2*). The slightly later stage of fig. 7 is particularly instructive. The abdomen now makes a short angle with the cephalothorax, so that the layer of ectoblast (*Ect.*) most to the left in the figure is the lining of the cephalothorax. The pulmonary stigma (*P. St.*) occupies the same relative position as in fig. 5, but the pulmonary sac or cavity (*P. Cav.*), which is lined on all sides by ectoblast, has become more voluminous and anterior extensions of it lead into three secondary lamellæ (*Lam. 2*). There is no longer any trace of the primary lamellæ. These had become gradually shorter in the successive stages, shown in figs. 2, 3, and 5, being only faintly marked in the last. There is no trace of them in the stage of fig. 7; were they present they should show just above the stigma (*P. St.*) on the mesial (right) side of the ectoblastic operculum. The primary lamellæ have not become the secondary lamellæ (*Lam. 2*), for the latter are directed cephalad and arise, as we have seen, from the solid anterior portion of the pulmonary primordium. These results are in essential agreement with those of Janeck, though in the form studied by him, *Lycosa*, the primary lamellæ are larger and more numerous, and by the fusion of their free ends with the mesial wall of the lung cavity give rise to a series of small cavities lined by ectoblast which ultimately close up. The primary lamellæ do not become the lamellæ of the adult, and, as Janeck has indicated, would seem to have no more morphological importance than the slight integumentary folds found on the mesial side of the proximal portion of the cephalothoracal appendages.

The history of the secondary or definitive lamellæ is as follows. Arising from the solid anterior region of the lung tissue, as shown in figs. 6 and 7, these lamellæ become larger and more cylindrical with narrower lamina (*Lam. 2*, fig. 8). Successive ones are formed from the solid mesial wall of the lung ingrowth, and in their growth they press into an archicœlic cavity (*Bl. Cav.*) between the ectoblast (*Ect.*) and mesoblast (*Mes.*). In fig. 9, Pl. XII, three of these secondary lamellæ

(*Lam. 2*) are shown; each contains a narrow canal communicating posteriorly with the main pulmonary cavity (*P. Cav.*) and their wall is lined by a very flattened epithelium; where the nuclei are placed there is a heightening of the cytoplasm around them, and the figure shows clearly the biserial arrangement of the nuclei, at certain intervals bicellular pillars occurring between adjacent lamellæ. The archicœlic space around these lamellæ has become a vascular cavity (*Bl. Cav.*), shown by stippling. A cross-section of the lung region of this stage is shown in fig. 10; in the vascular cavity (*Bl. Cav.*) lie the lamellæ (*Lam. 2*) which are seen to be flattened tubes. The last stage I have been interested to examine is that of fig. 11, one of about nine days (hatching usually takes place in the fifteenth day). Five lamellæ are developed, but owing to obliquity of the section none are seen in their full length.[5] Mesial to them (to the right in the figure) there is an ectoblastic layer (*Ect.*), from which further lamellæ will be formed. The relation of the bicellular pillars to the lamellæ and to the blood cavity (*Bl. Cav.*) is perfectly clear.

Thus each lung-book arises in the region of the appendage of the second abdominal segment. Immediately behind this appendage develops an ectoblastic invagination, the stigma and pulmonary chamber, and into this the appendage invaginates. There are temporary lamellæ on the posterior surface of this appendage, and these come to lie within the pulmonary chamber, but they disappear entirely and from a thickened cell mass of the anterior region of the invagination the secondary or definitive lamellæ develop. The appendage thereby forms both operculum and secondary lamellæ.

4. Genetic Relations of the Tracheæ and Lung-books of Araneads.

In the Araneæ theraphosæ there are two pairs of lung-books and no tracheæ, and this is also the case in the Hypochilidæ among the Araneæ veræ. Nothing is known of the development of these organs in these forms, except my observation that in *Evagrus* the lung-books are derivations of the second and third abdominal segments. All other Araneæ veræ with two exceptions have one pair of lung-books and an unpaired or paired (Dysderidæ) tracheal stigma; the exceptions are the Caponiidæ with four tracheal stigmata, but no lung-books, and the Pholcidæ with one pair of lung-books, but with no tracheæ or only very rudimentary ones (Lamy, 1902).

---

[5] It will be noted that all the drawings on Plate XI are made to the same scale, yet in some cases, as on comparison of fig. 3 with figs. 2 and 5, the parts and nuclei of one embryo may be much smaller than in another embryo of approximately the same age. This is because there are great individual differences in the size of eggs, so of the size of the cells that compose them. The number of cells appears to be constant for a particular stage, but the size of the cells depends upon the size of the embryo.

There has been much discussion as to the genetic relations of these two organs. They have been so fully and ably compared by Lamy that it is not necessary to more than summarize his account. Since the time of Leuckart (1849) all writers on the subject seem to conclude an essential homodynamy of lung-books and tracheæ, save Berteaux (1889), who, however, reached quite an erroneous idea of the structure of the pulmonary lamellæ. But three different opinions have arisen, namely, whether the lungs are modified tracheæ, the tracheæ modified lungs, or both derived from a common ancestral organ. That the lungs are modified tracheæ is held by Leuckart (1849), Leydig (1855), Bertkau (1872), Schimkewitsch (1884, 1887), Croneberg (1888), Schneider (1892), Sinclair (1892), v. Kennel (1892), Jaworowski (1894), Lamy (1902), and Janeck (1909). That the tracheæ are derived from lung-books is maintained by Lankester (1881), MacLeod (1884), Kingsley (1893), Simmons (1895), Laurie (1894), Wagner (1895) and Kishinouye (1890)—this group of naturalists being mainly influenced by the Limulus-ancestry theory. Finally, Weissenborn (1886) and Bernard (1893) hold that lung-books and tracheæ are divergent derivatives of a common ancestral organ, in the one case from tracheæ of the type of *Peripatus*, in the other from acicular glands of Annelids.

In their adult condition lungs and tracheæ are both branched cavities lined by cuticulated hypodermis. In the lung-books the branches are flattened lamellæ placed parallel, in the tracheæ the branches are usually cylindrical ramifying tubes. But sometimes the main tracheal trunk has no branches, and sometimes the branches are arranged in parallel bundles, all of which details have been described by Lamy; further, I have noticed in *Loxosceles* that the large median tracheal trunk is excessivcly compressed, quite as much as a pulmonary lamella. Further, tracheæ and lung-books may replace each other in both the second and third abdominal segments. Therefore there are no radical anatomical differences between the two.

Ontogenetically both arise as ectoblastic invaginations, and there is a vestibulum in each case. But there are four differences in the development: (1) In the case of the lung-books the abdominal appendage invaginates and the wall of the part so invaginated bounds the main pulmonary chamber, while the external surface of the appendage becomes the operculum. In the case of the trachea the abdominal appendage does not invaginate, but disappears by merging with the surrounding ectoblast, the trachea arises after it has disappeared, the tracheal vestibulum is not formed from this appendage, and there is no operculum. (2) The pulmonary stigma arises immediately behind its appendage, but the tracheal stigma develops more or less behind the original position of the appendage of its segment. (3) The pulmonary lamellæ arise from a thickened solid cell mass, which is not the case with the tracheal branches. (4) The tracheæ appear somewhat later in the ontogeny.

Thus while the anatomical differences are not great the ontogenetic are considerable. The most important difference is that the lung-books develop from appendages. On the basis of this particular difference we must conclude that there is no complete homodynamy between the two sets of organs, but an incomplete resemblance. The trachea exhibits a simpler method of formation, but this in itself need speak no more for primitiveness than for degeneracy. The present evidence does not clearly indicate which is the more primitive.

5. Limulus and the Arachnids.

To one question, however, we may take a more decided stand—that, namely, of the reference of aranead lung-books to the branchiæ of *Limulus*. Since Straus-Durckheim (1829) first insisted that *Limulus* is much more closely related to Arachnids than to Crustaceans, this view has grown steadily in support, especially in the hands of E. Van Beneden (1871), A. Milne-Edwards (1873), Barrois (1878), Lankester (1881), Patten (1890) and Kingsley (1893). And there can be little question that *Limulus* and the Arachnids are related, from the correspondence in segmentation, arrangement and number of appendages, endosternal and entapophysial structures, central nervous and vascular systems and other organs, all of which have been carefully compared by Lankester and Kingsley. The principal difference between the two has been considered the respiratory organs, and Lankester sought to obviate this by reasoning that the lung-books of Arachnids arose by the invagination of lamelligerous branchial appendages, and that the tracheæ are in their turn modifications of lung-books. This view seemed to be confirmed by the accounts of the development of arachnidan lung-books as given for spiders by Kishinouye, Purcell and Simmons, and for the scorpion by Brauer (1895).[6]

---

[6] Brauer's study did not determine the first origin of the pulmonary lamellæ, for there is a gap between the stages shown in his text figs. 15*b* and *c*.

Simmons insisted on the following points: (1) that primary folds appear very early on the posterior surface of the invaginating pulmonary appendage of the spider, resembling very closely in position the gill-leaf development of *Limulus* as described by Kingsley; and (2) that such folds become the pulmonary lamellæ of the adult spider. But Janeck and I demonstrate that these primary lamellæ of the spider are only temporary, with probably no more significance than the folds on the mesial surfaces of the cephalothoracal appendages, and they certainly do not become the definitive lamellæ of the lung-book. The truth is that the secondary pulmonary plates of the spider do not arise from folds on the outer surface of an appendage, but in a different position from a solid cell mass after the appendage has invaginated.

Therefore there is nothing in the ontogeny of the lung-books of spiders similar to the development of the gills of the Xiphosura, beyond that they are both connected with abdominal appendages; consequently no embryological ground for deriving the lung-books from gills.

Further, objections of a theoretical nature may also be made against the derivation of the lung-books from gills. First, the direct change of a water-breathing organ into an air-breathing one would be almost without parallel; at least I cannot recall any instance of this kind in animals. Second, granted that *Limulus* is genetically related with arachnids, a view to which I subscribe, what reason have we for assuming that *Limulus* is the more primitive form? The only good anatomical argument for this view is that *Limulus* retains through life six pairs of abdominal appendages, and also a pair of nephridia. The general reason for the primitiveness of *Limulus* is its marine habitude, with the assumption that the ancestors of most groups must have originated in the seas. The latter assumption lacks all solid basis, and has been opposed by Simroth (1891) and myself (1906). But the true arachnids are essentially terrestrial, quite as much as the insects are, and though a few have taken to aquatic existence, such as the Hydrachnids and *Argyroneta,* all of them breathe atmospheric air. Further, true araneads occurred in the Carboniferous, in times as early as the first fossil traces of Limuloids, while terrestrial scorpions existed in the Silurian. These facts would indicate that the true arachnids originated on the land. It would, accordingly, seem to me that if *Limulus* be related to the arachnid stock, and this seems well established, that the former represents a line of descent that has taken secondarily to aquatic life; and for this view would speak also its existence in shoal waters, and its behavior in laying its eggs close to the land. The position I have taken is in direct opposition to the general one as voiced by Korschelt and Heider, "that the Arachnida have developed from the Paleostraca by adaptation to land life."

6. The Taxonomic Rank of the Theraphosæ.

By quite general consent arachnologists consider the Araneæ theraphosæ to be more primitive than the Araneæ veræ. I do not know whether this conclusion has at any time been critically discussed, and in the present place I shall touch on it only briefly and tentatively, for I feel my knowledge of the families of spiders is too deficient for me to attempt to make any positive decision.

The Theraphosæ differ from the Araneæ veræ in having the chelicera directed forward instead of downward, in possessing no tracheæ, and in having no maxillary plates on the pedipalp (except in certain Atypidæ).

We cannot say whether the character of the position of the chelicera is more primitive in the first case than the other. The lack of maxillary plates might or might not be due to degeneration, and we have seen that there is no good basis for deciding whether lung-books are more primitive than tracheæ.

Thus these anatomical differences in themselves furnish no good answer to our question. The Liphistiids in their general structure appear decidedly primitive, with their four pairs of functional spinnerets and their segmented abdominal terga; yet Simon (1908) in his recent description of the male of *Liphistius birmanicus* has shown that the palpal bulbus is much more complex than in other Theraphosids.

Excluding the Liphistiidæ, the other families of the Theraphosæ, namely, the Aviculariidæ and the Atypidæ, would seem to be degenerate in one respect, that of the spinnerets. For they possess neither colulus nor cribellum, and almost all the Aviculariids lack also the anterior spinnerets. The great length and appendage-like appearance of the posterior spinnerets in the Aviculariids might not be a primitive character, but be due to compensatory growth on account of the loss of the anterior spinnerets. The general small size and compact grouping of the eyes might well be the result of the usual tubicolous mode of life. Further, there are certain Araneæ veræ (such as *Filistata*) which show the male copulatory bulbus less complex than in the Theraphosæ.

In the loss of the spinnerets of the fourth abdominal segment, in the small size of the eyes, and in the occasional great volume of the body the Aviculariidæ at least would seem to be considerably modified. They might well be considered a modified branch which has to great extent replaced spinning by burrowing. Few of them construct true snares, and then only simple ones. Thus they might stand in somewhat the same relation to the Araneæ veræ, as the Ratitæ do to the Carinatæ among birds.

While this hypothesis of the systematic rank of the Aviculariidæ may appear reasonable, we can hardly at the present time decide the rank of the Liphistiidæ and Atypidæ, or indeed decide whether the Theraphosæ represent a homogeneous group.

LITERATURE LIST.

BALFOUR, F. M. 1880. Notes on the Development of the Araneina. Quart. Journ. Micr. Sci. (2), 20.
BARROIS, J. 1878. Sur la développement des Araignées. Journ. Anat. et Physiol. 14.
BENEDEN, E. VAN. 1871. De la Place que les Limules doivent occuper dans la classification des Arthropodes, etc. Ann. Soc. Entom. Belgique, 15.
BERNARD, H. M. 1893. Additional Notes on the Origin of the Tracheæ from Setiparous Glands. Ann. Mag. Nat. Hist. (6), 11.
BERTEAUX, L. 1889. Le poumon des Arachnides. La Cellule, 5.
BERTKAU, P. 1872. Ueber die Respirationsorgane der Araneen. Arch. Naturgesch., 38.
Idem. 1882. Ueber das Cribellum und Calamistrum. *Ibid.*, 48.
BLACKWALL, J. 1839. On the number and structure of the mammulæ employed by Spiders in the process of spinning. Trans. Linn. Soc. London, 18.
BRAUER, A. 1895. Beiträge zur Kenntnis der Entwicklungsgeschichte des Skorpions. 2. Zeit. wiss. Zool., 59.
BRUCE, A. T. 1887. Observations on the Embryology of Insects and Arachnids. Baltimore.

CLAPARÈDE, E. 1862. Recherches sur l'évolution des Araignées. Utrecht.
CRONEBERG, A. 1888. Beitrag zur Kenntniss des Baues der Pseudoscorpione. Bull. Soc. Imp. Natural. Moscou (2), 2.

DAHL, F. 1901. Ueber den Werth des Cribellums und Calamistrums, etc. Sitzungsber. Ges. Naturf. Fr., Berlin.
Idem. 1904. Ueber das System der Spinnen (Araneæ). Sitzungsber. Ges. Natur-forsch. Fr. Berlin.

JANECK, R. 1909. Die Entwicklung der Blättertracheen und der Tracheen bei den Spinnen. Jena. Zeit. 44.
JAWOROWSKI, A. 1894. Die Entwicklung der sogenannnten Lungen bei den Arachniden, etc. Zeit. wiss. Zool., 58.
Idem. 1895. Die Entwickelung des Spinnapparates bei Trochosa singoriensis Laxm., etc. Jena. Zeit., 30.

KENNEL, J. v. 1892. Die Verwandtschaftsverhältnisse der Arthropoden. Schriften Natur. Ges. Univ. Dorpat, 6.
KINGSLEY, J. S. 1893. The Embryology of Limulus. Part 2. Journ. Morph., 8.
KISHINOUYE, K. 1890. On the Development of Araneina. Journ. Coll. Sci. Japan, 4.
KORSCHELT, E., und K. HEIDER. 1892. Lehrbuch der vergleichenden Entwicklungsgeschichte der wirbellosen Thiere. 2. Jena.

LAMY, E. 1902. Recherches anatomiques sur les trachées des Araignées. Thèse. Paris.

Lankester, E. R. 1881. Limulus an Arachnid. Quart. Journ. Micr. Sci. (2), 21.

Laurie, M. 1894. On the Morphology of the Pedipalpi. Journ. Linn. Soc., London, 25.

Leuckart, E. 1849. Ueber den Bau und die Bedeutung der sog. Lungen bei den Arachniden. Zeit. wiss. Zool., 1.

Leydig, F. 1855. Zum feineren Bau der Arthropoden. Müller's Arch.

Locy, W. A. 1886. Observations on the Development of Agelena nævia. Bull. Mus. Zool. Harvard, 12.

MacLeod, J. 1884. Recherches sur la structure et la signification de l'appareil respiratoire des Arachnides. Arch. de Biol., 5.

Menge, A. 1843. Ueber die Lebensweise der Arachniden. Neueste Schr. Naturf. Ges. Danzig, 4

Milne-Edwards, A. 1873. Recherches sur l'Anatomie des Limules. Ann. Sci. Nat. (5), 17.

Montgomery, T. H., Jr. 1906. The Analysis of Racial Descent in Animals. New York.

Morin, J. 1887. Zur Entwicklungsgeschichte der Spinnen. Biol. Centralbl., 6.

Patten, W. 1890. On the Origin of Vertebrates from Arachnids. Quart. Journ. Micr. Sci. (2), 31.

Purcell, F. 1895. Note on the Development of the Lungs, Entapophyses, Tracheæ and Genital Ducts in Spiders. Zool. Anz., 18.

Salensky, W. 1871. (Development of Araneads. Russian.) Sapiski Ges. Naturf. Kiew. 32.

Schimkewitsch, W. 1884. Zur Entwicklungsgeschichte der Araneen. Zool. Anz., 7.

Idem. 1887. Étude sur le développement des Araignées. Arch. de Biol.. 56.

Schneider, A. 1892. Mélanges arachnologiques. Tablettes Zoologiques, Poitiers, 2.

Simmons, O. L. 1894. Development of the Lungs of Spiders. Amer. Journ. Sci. (2), 48. Tufts College Studies, 2.

Simon, E. 1892. Histoire Naturelle des Araignées. 2^{me} éd. 1. Paris.

Idem. 1908. Étude sur les arachnides du Tonkin. Bull. sc. France et Belgique, 43.

Simroth, H. 1891. Die Entstehung der Landtiere, Leipzig.

Sinclair, F. G. 1892. A new Mode of Respiration in the Myriapoda. Ann. Mag. Nat. Hist. (6), 9.

Stevenson, C. W. 1908. On the Spinning Organs and Architecture of Evagrus, a Theraphosid Aranead. Biol. Bull, 15.

Straus-Durckheim. 1829. Appendix to Vol. 6 of French translation of Meckel's Comparative Anatomy (*fide* Lankester).

Thorell, T. 1870. Remarks on Synonyms of European Spiders. Upsala.

Wagner, J. 1895. Beiträge zur Phylogenie der Arachniden. Jena. Zeit., 29

Wallstabe, P. 1908. Beiträge zur Kenntnis der Entwicklungsgeschichte der Araneinen. Zool. Jahrb., 26.

Weissenborn, B. 1886. Beiträge zur Phylogenie der Arachniden. *Ibid.*

Explanation of Plates XI, XII, XIII, XIV.

All the figures have been made by the author with the aid of the camera lucida, and in each the anterior region is directed upwards, In the lettering of the plates the following abbreviations have been employed:

1–11, abdominal segments 1 to 11.
1 G.–11 G., ganglia of the preceding.
2 Ap.–5 Ap., appendages of abdominal segments 2–5.
An., anus.
A. Sp., anterior spinneret.
Bl. Cav., blood cavity.
Chel., cheliceron.
C. L., caudal lobe.
Cœl., cœlom.

Col., colulus.
Cr., cribellum.
Cr. Pl., spinning plate of cribellum.
Ect., ectoblast.
H., heart.
L. 1–L. 4, ambulatory limbs 1–4.
L. 1 G.–L. 4 G., ganglia of the preceding.
Lam. 1, primary lamella of lung-book.
Lam. 2, secondary lamella of lung-book.
M., muscle.
Mes., mesoblast.
M. Sp., median spinneret.
N. C., nerve cord.
P. Cav., ectoblastic cavity of lung-book.
Ped., pedicel of abdomen.
P. Sp., posterior spinneret.
P. St., pulmonary stigma.
Pul., lung-book.
R. B., rectal bladder (stercoral pocket).
Ros., rostrum.
Sp., spinneret.
Sp. Gl., spinning gland.
Tr., trachea.
T. St., tracheal stigma and vestibulum.
x., ectoblastic thickening of undetermined significance.

Plate XI.—Theridium tepidariorum.—Oblique longitudinal sections through the lung-book region, all drawn to the same scale.
Fig. 1.—About 98 hours.
Fig. 2.—About 127 hours.
Figs. 3, 4.—121 hours; fig. 3 through the stigma, and fig. 4 somewhat lateral to it, of the same lung-book.
Fig. 5.—Of another embryo of 121 hours.
Fig. 6.—Of another embryo of 121 hours, to one side of the stigma.
Fig. 7.—145 hours.
Fig. 8.—145 hours.

Plate XII.—Theridium tepidariorum.—All the figures except 16 drawn to the same scale.
Fig. 9. Longitudinal section of lung-book, about 150 hours.
Fig. 10.—Oblique cross-section of lung-book of an embryo of the same age.
Fig. 11.—Longitudinal section of a lung-book, the lamellæ not shown in their full length, about 218 hours.
Fig. 12.—Longitudinal section through pulmonary and tracheal stigma, 145 hours.
Fig. 13.—Median section of tracheal stigma, 168 hours.
Fig. 14.—Median section of trachea, about 218 hours.
Fig. 15.—Median section of trachea, 15 days.
Fig. 16.—Oblique dorso-lateral surface view of embryo of about 127 hours.

Plate XIII.—Loxosceles.—Figs. 17–24 are surface views of whole-stained embryos drawn to the same scale, in figs. 17–19 the extra-embryonic area being stippled.
Fig. 17.—Postero-ventral, 190 hours (8 days).
Fig. 18.—Postero-ventral, 170 hours (7 days).
Fig. 19.—Postero-lateral, 170 hours (7 days).
Fig. 20.—Lateral, 218 hours (9 days).
Fig. 21.—Ventral.
Fig. 22.—Abdomen, ventral, 265 hours (11 days).
Fig. 23.—Abdomen, ventral, 14 days.
Fig. 24.—Abdomen, ventral, 20 days, the hypodermal hairs not drawn.
Fig. 25.—Median longitudinal section of the colulus of an adult, its free apex at the left and its dorsal surface above.
Fig. 26.—Ventral view of colulus and spinnerets of an adult female, from an unstained balsam mount.
Fig. 27.—Adult vestibulum and roots of main tracheal branches, caustic potash preparation.

Plate XIV.—Evagrus, Filistata, Dictyna, Hyptiotes.—Figs. 28–32 are drawn to the same scale.
Fig. 28.—*Evagrus*, lateral view of embryo before reversion.

Fig. 29.—*Evagrus,* ventral view of abdomen shortly after reversion; the dotted line in the upper portion of the figure indicates where the cephalothorax had been broken off and a part of the abdomen removed.

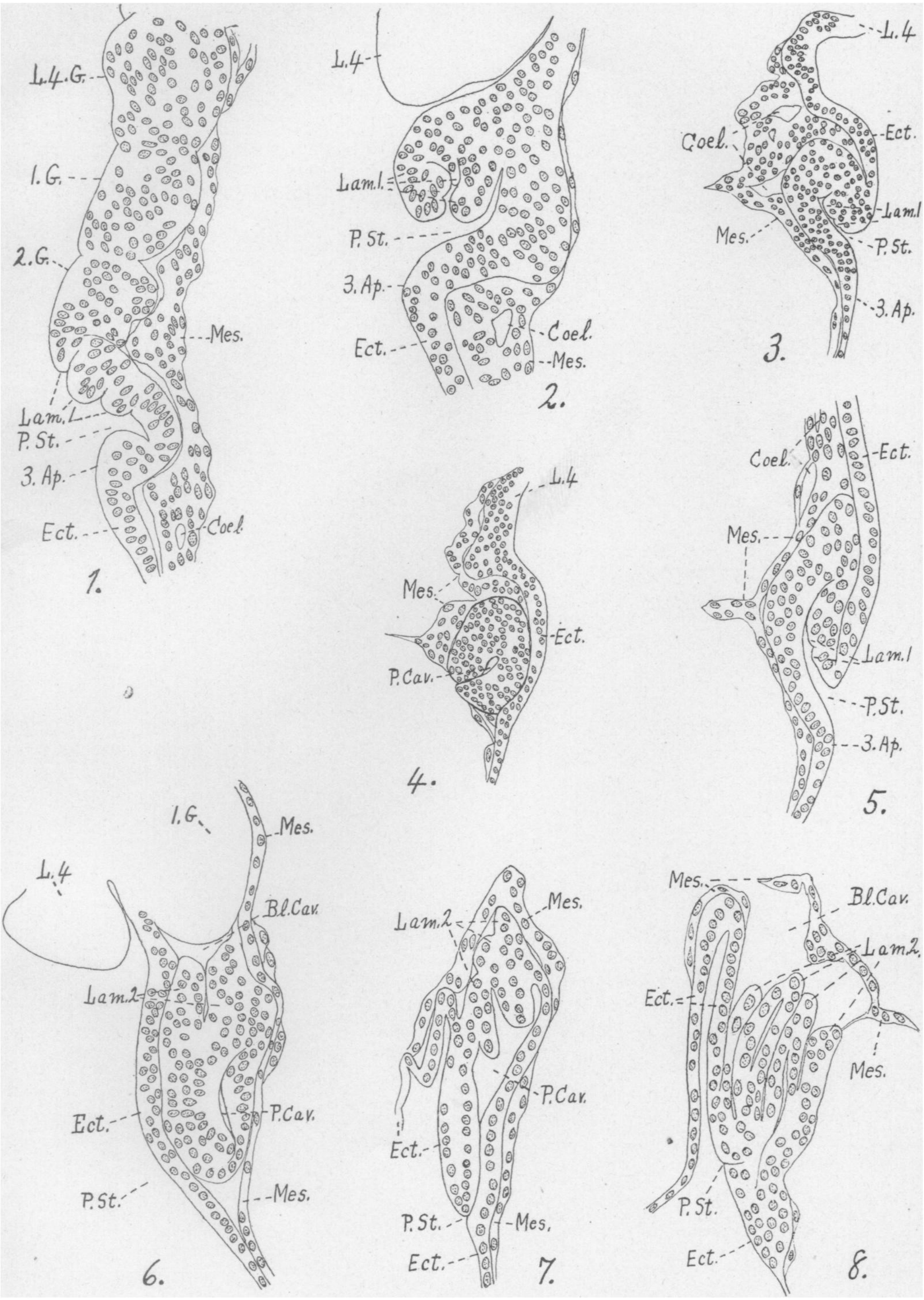
Figs. 30–32.—*Evagrus,* ventral views of abdomina of successive later stages, fig. 32 of an embryo of 19 days (just hatching).

Fig. 33.—*Filistata,* ventral view of abdomen of embryo shortly after reversion.

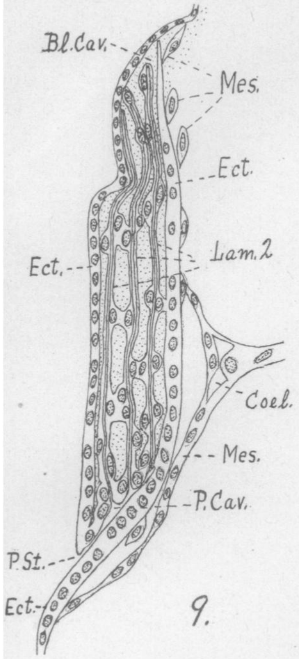
Fig. 34.—*Filistata,* ventral view of cribellum of adult female, balsam mount.

Fig. 35.—*Dictyna volupis,* ventral view of cribellum and tracheal vestibulum of adult female, balsam mount.

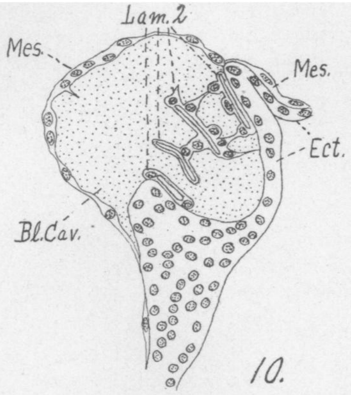
Fig. 36.—*Hyptiotes cavatus,* ventral view of cribellum of adult female, balsam mount.



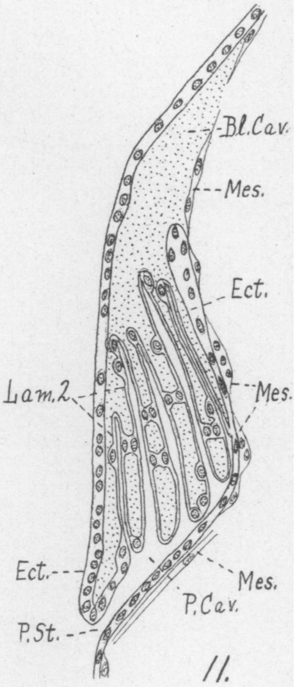
MONTGOMERY. THE SPINNERETS, ETC., OF ARANEIDS.



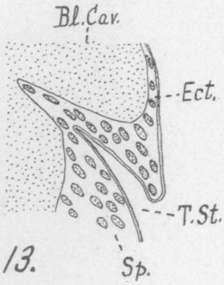
9.



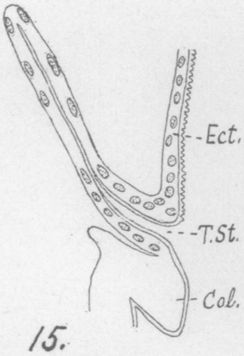
10.



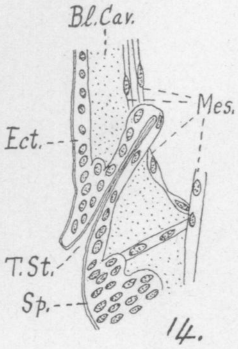
11.



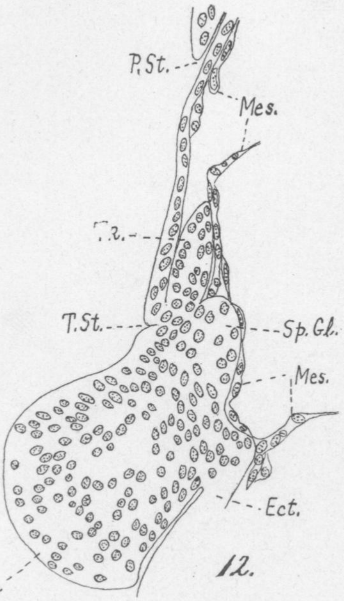
13.



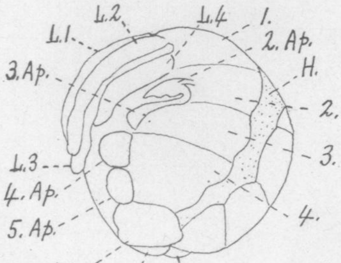
15.



14.

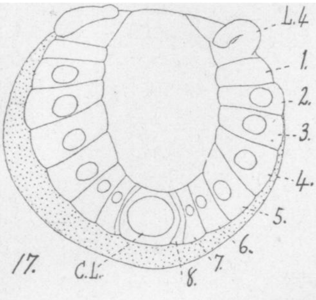


12.

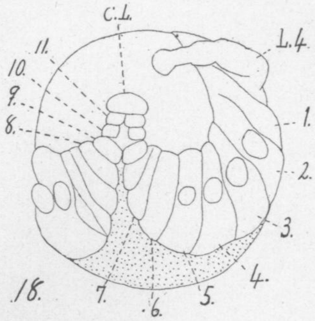


16.

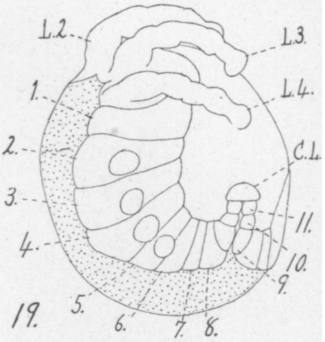
MONTGOMERY. THE SPINNERETS, ETC., OF ARANEIDS.



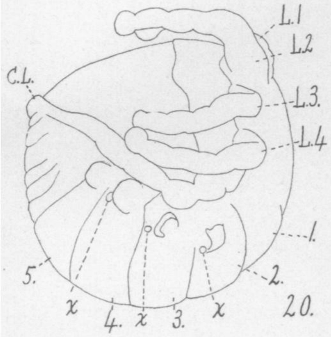
17.



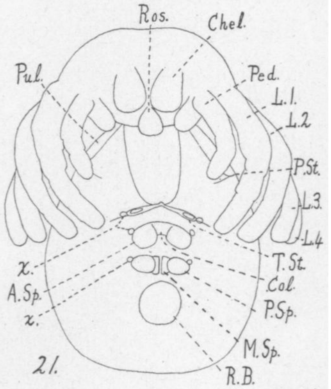
18.



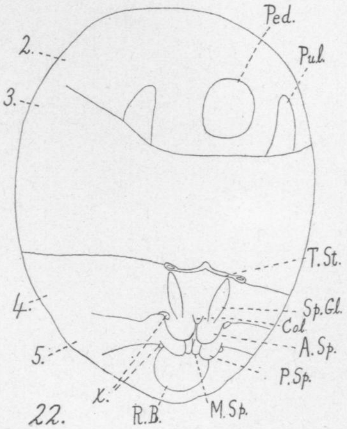
19.



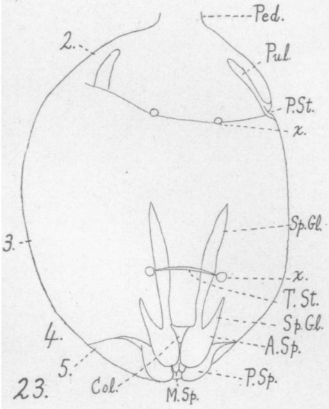
20.



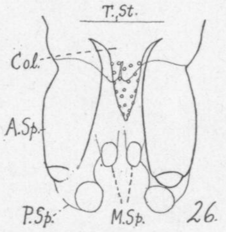
21.



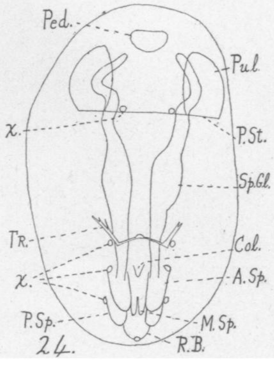
22.



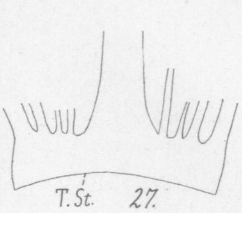
23.



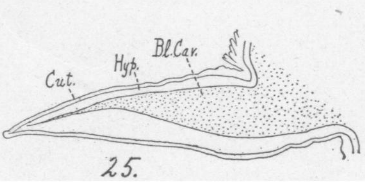
26.



24.

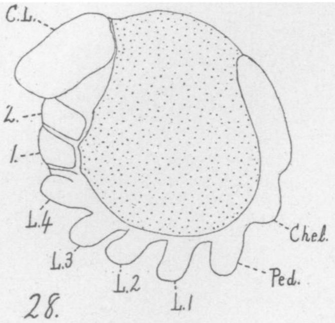


27.

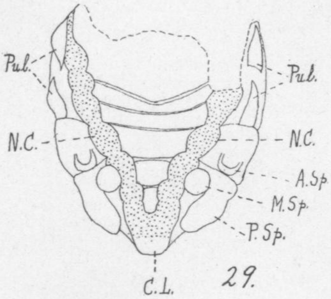


25.

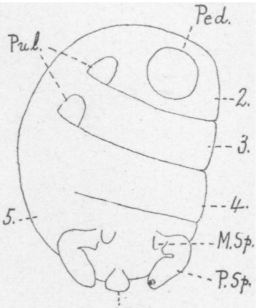
MONTGOMERY. THE SPINNERETS, ETC., OF ARANEIDS



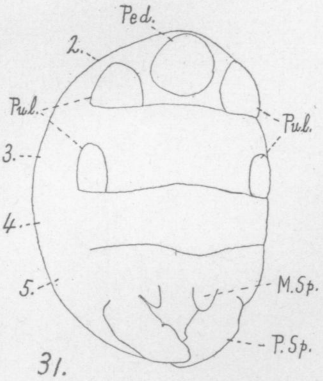
28.



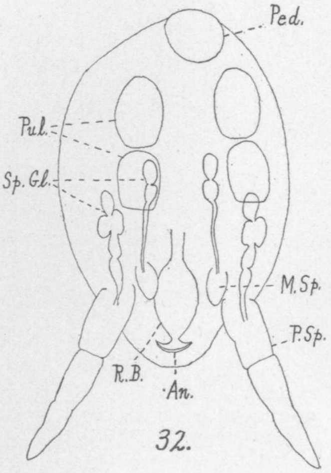
29.



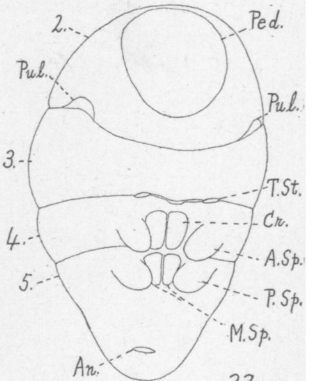
30.



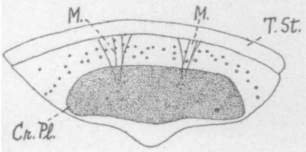
31.



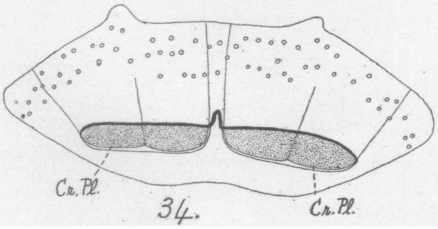
32.



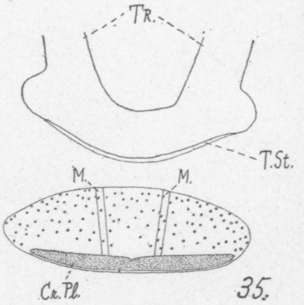
33.



36.



34.



35.

MONTGOMERY. THE SPINNERETS OF ARANEIDS.